Mobility of Tomorrow – Research Topics of DLR-FK

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Mobility of Tomorrow – Research Topics of DLR-FK

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The DLR at a Glance – Aeronautics and Ground Based Transportation?

Locations and Research Areas

The German Aerospace Center (DLR) is the national aeronautics and space research center of the Federal Republic of Germany.

DLR has approximately 8000 employees at 20 locations in Germany and international offices in Brussels, Paris, Tokyo and Washington D.C.

- Aeronautics
- Space Research and Technology
- **Energy and Transport**
- Defence and Security
- Space Administration
- Project Management Agency

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The DLR at a Glance – Aeronautics and Ground Based Transportation?

Superior Goals

- Assurance of mobility
- Protection of environment and resources
- Improvement of safety

Strategic basis elements

- Independent transport strategy
- Extension of the transport-specific range of skills
- Use of DLR internal synergies
- Intensified focus on applications
- Complex systems research
- Design and use of large-scale plant
- Cooperation with excellent partners from industry and science on a strategic basis

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The DLR at a Glance – Aeronautics and Ground Based Transportation?

Challenges for the transport system:

Ecological damage

- **18 percent** of **CO2 emission** attributable to transport sector
- **1.3 kg CO2** on **4.5 km** drive when looking for parking space

Traffic jam

- Population growth, urbanization and growth of freight transport
- Every car driver spends **38 hours** per year in **traffic jam**
- cf. average travel speed in Beijing: **7,5 mph**

Accidents

- **3,475 fatalities** and **393,744 casualties** in road traffic (2015)
- **88 percent** of accidents are caused by **drivers' mistake**

Mobility in old age

- Demography: **share of over 65 year-old** rises from today 21 percent to **27.5 percent** in 2030

Digitalization

- individual, intermodal, efficient through **information** and **communication**
- business models are changing from **product- to user-oriented**

Source: Prof. Karsten Lemmer, DLR, (2016) Presentation „Fragen zukünftiger Mobilität"

All numbers for Germany. Sources: Verkehr in Zahlen 2015/2016; Centre for Economics and Business Research 2014; [illegible] PARKING Parkplatz [illegible] 2016; Ergebnisse der 13. koordinierten Bevölkerungsvorausberechnung, Statistisches Bundesamt 2015; average travel speed Beijing UBS; transport for London, 2011; Darstellung [illegible] Bilder: shutterstock.com: Khongkit Wiriyaphan, Dmitry Lobanov, Illya Ovchinnikov, [illegible]

DLR

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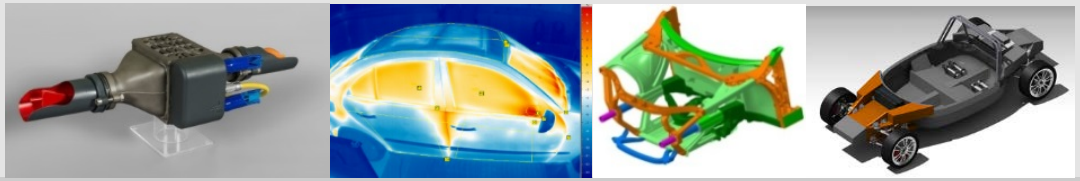
Institute for Vehicle Concepts – Our Vision

- We count among the best system-institutes in Europe

…for **innovative** road and rail **vehicle concepts**

- We are a nationally and internationally requested provider of research and development services

…for a holistic, systemic **vehicle concepts** and selected **leading-edge-technologies**



- We take a leading position in the relationships with our customers and business partners
-
- We provide through our engineering results significant contributions to the HGF-program

- We make safe and interesting jobs with our most important asset: continuous educated employees

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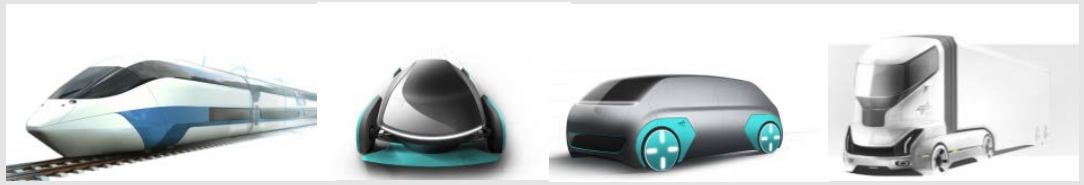
Institute for Vehicle Concepts – Our Mission

- We research, develop and evaluate

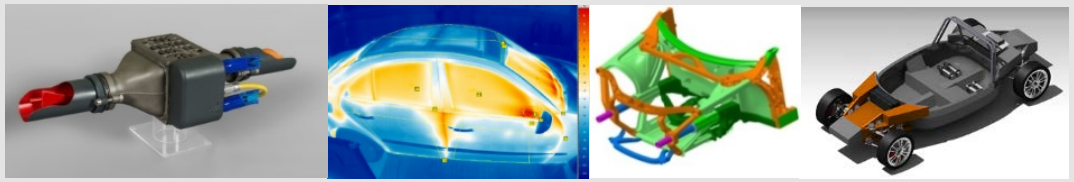
…**innovative vehicle concepts**
for road and rail



- Design, development and evaluation of application-oriented technical solutions within the overall vehicle system

- We provide research and development services in the areas

  - Increase the energy efficiency
  - Reduction of running resistance
  - Systemic relevant vehicle technologies



- We improve the offer of lectures and the policy consultation by engineer-scientific results

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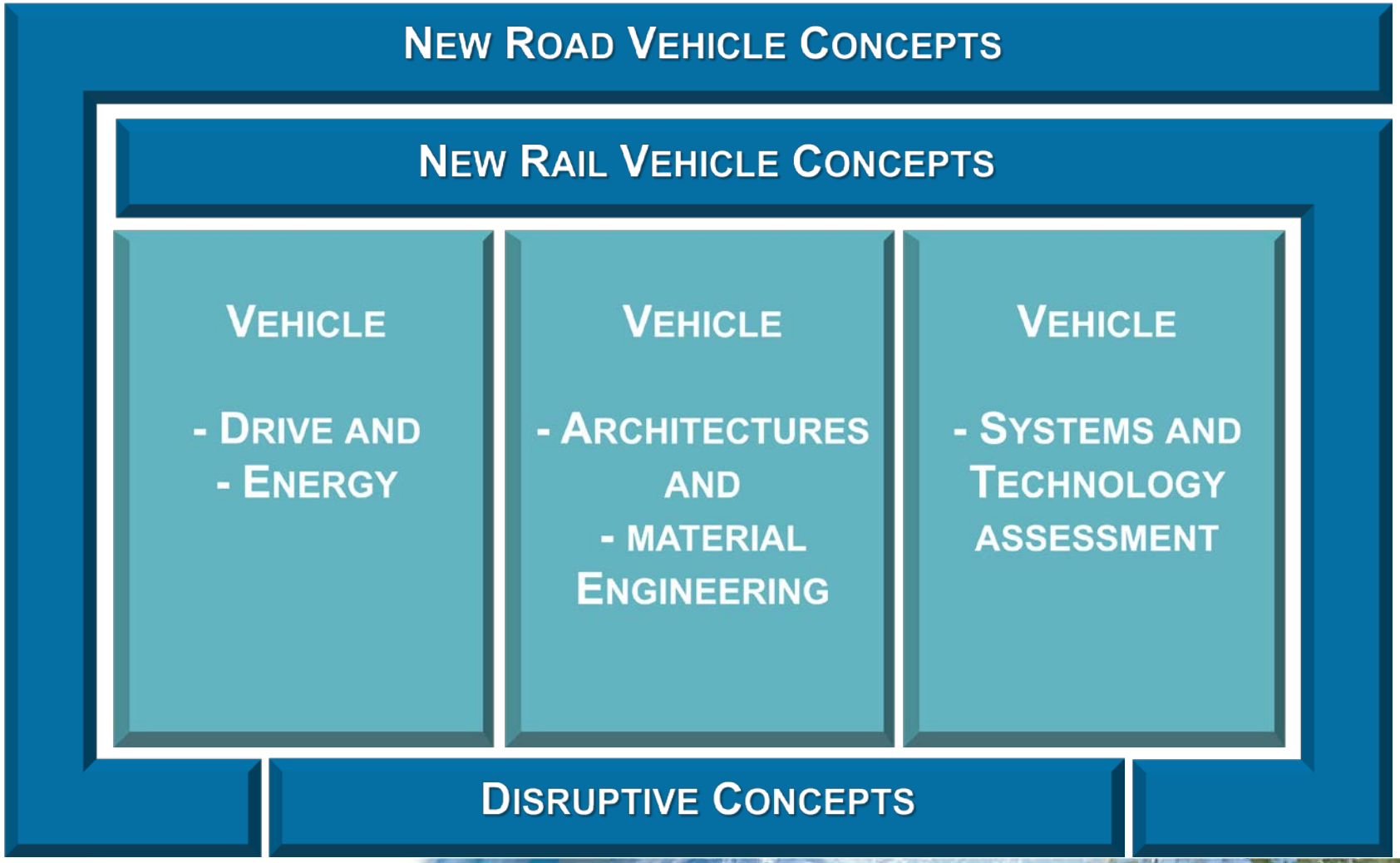
Institute for Vehicle Concepts – The 6 Fields of Innovation



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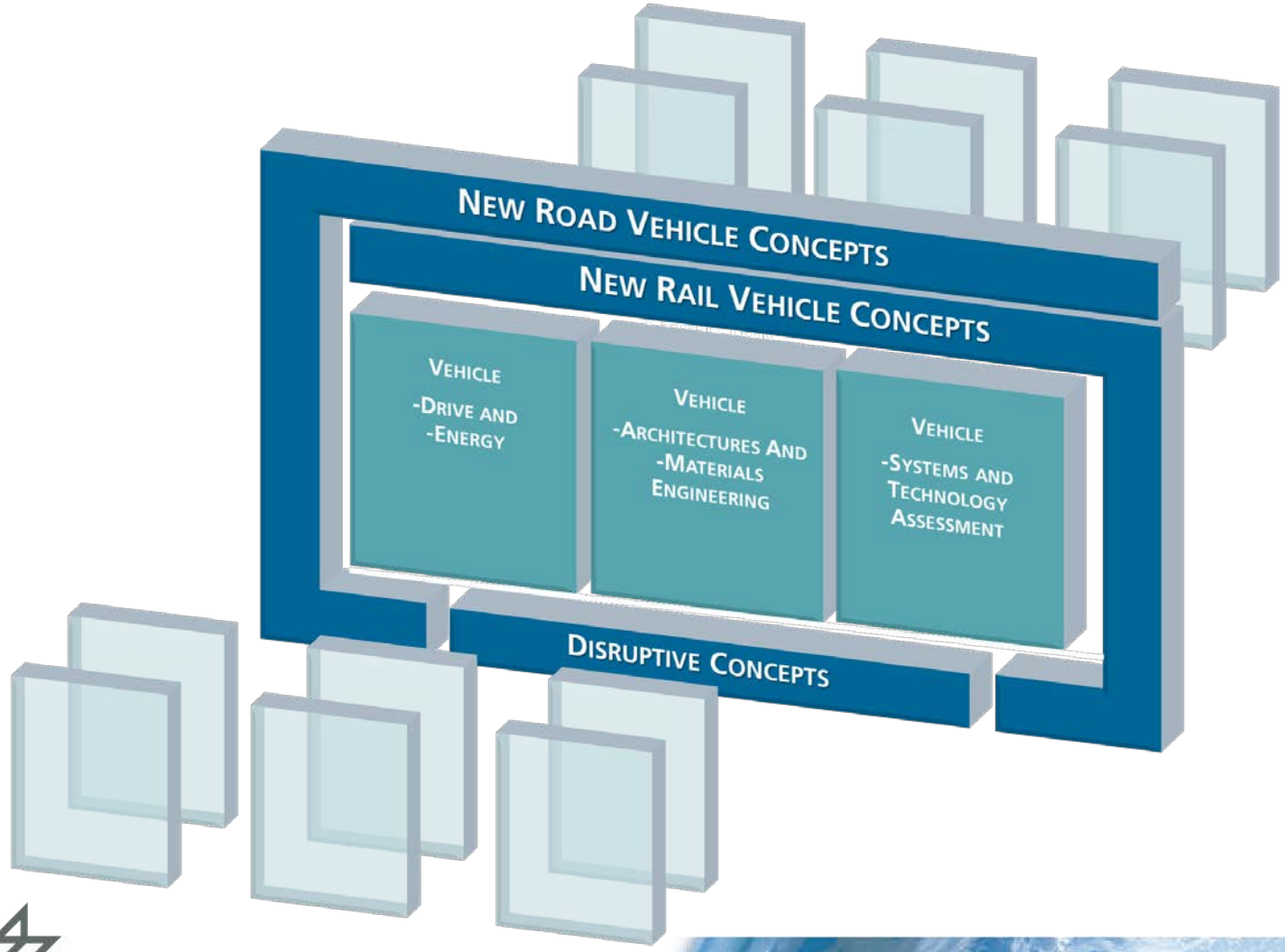
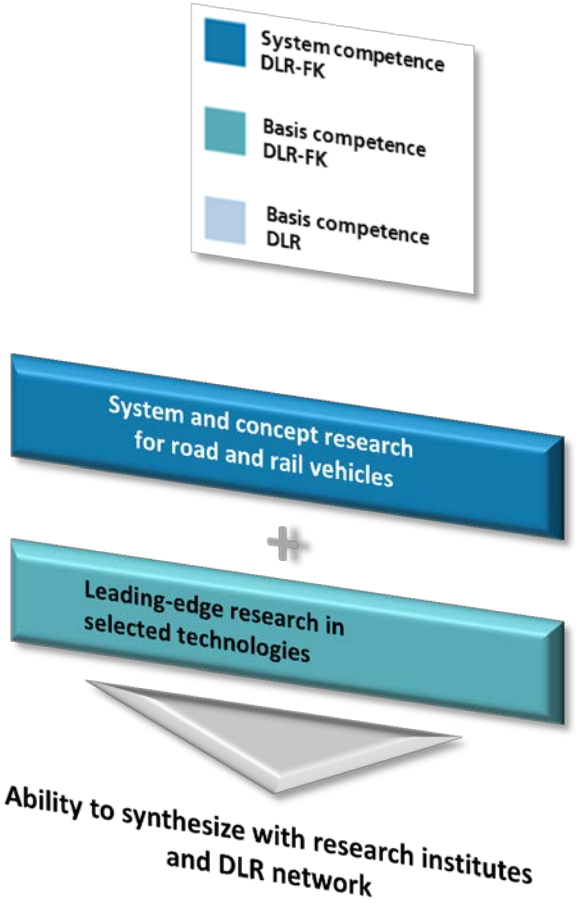
Institute for Vehicle Concepts – The 6 Fields of Innovation





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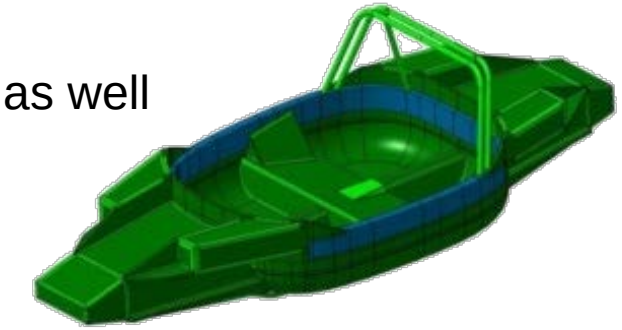
Institute for Vehicle Concepts – Innovation Field: New Road Vehicle Concepts



Motivation

- New user and logistics concepts, resource shortage and environmental pollution as well as increasing urbanization require novel vehicle-concepts and technologies.

Research Tasks

- Draft and demonstrators of innovative vehicles concepts
- Research and holistic assessment of new technical solutions

Key Results

- VECTOR21 scenario model for motor vehicle and commercial vehicle drives
- Concept family Next Generation Car (NGC)
  - Urban Modular, Safe Light Regional and Interurban Vehicle
- fuel cell demonstrator
- Modularization and platform strategies
- Urban Vehicle and Mobility concepts

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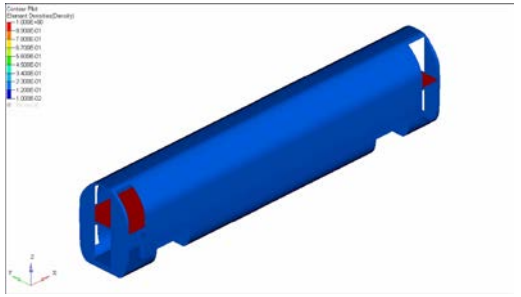
Institute for Vehicle Concepts – Innovation Field: New Rail Vehicle Concepts

Motivation

- Mass transport between megacities and energy efficiency set the boundary conditions for rail transport.

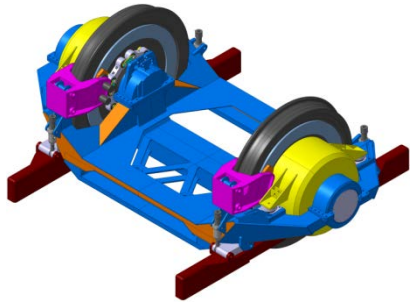
Research Tasks

- Novel multiple unit concepts & Increase energy efficiency



Key Results

- Concept family Next Generation Train (NGT)
  - High speed train NGT-HGV
  - Commuter Train NGT LINK with hybrid drive concepts
  - High speed Cargo Train NGT CARGO



- Novel access concept for the middle carriages in double decker design
- Contactless energy transmission (FEÜ) & Wheel-integrated power trains
- Software tools for evaluating high speed traffic potentials HGV, LCA and Modelica-library
- Railway Station Concept Next Generation Station (NGS)

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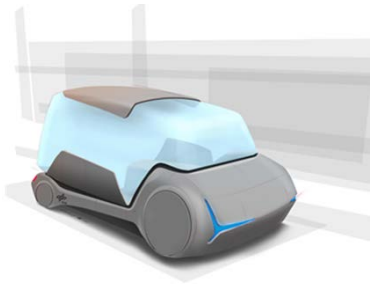
Institute for Vehicle Concepts – Innovation Field: Alternative/Disruptive Concepts

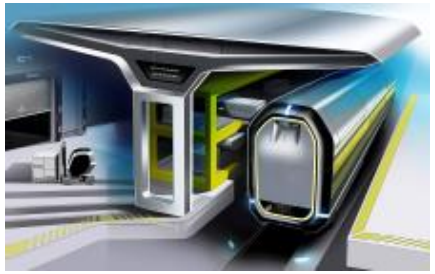
Motivation

- Disruptive solutions enable new business models and support the transformation process within the automotive industry
- Research on the disruptive mobility and transportation solutions as well as their impact on the future design of vehicle concepts and technologies



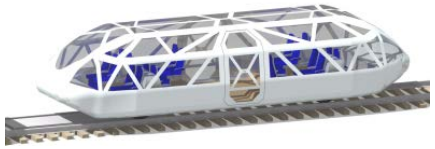
Research Tasks

- Identification, derivation and motivation of user oriented vehicle concepts as a result of rising individualization
- Dimensioning of enabling technologies
- Analyzing the individual demand on mobility and transportation of express deliveries, trade and industry
- Revealing of use cases and new business models, consideration of all transportation modes



Key Results

- Skofi Study with the vehicles: FTRM und LHRT
- BMBF-application „MAUDE“: Auto-Dis



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Institute for Vehicle Concepts – Innovation Field: Vehicle Drive and Energy

Motivation

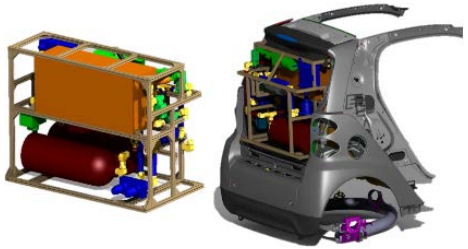
- The combustion engine (hybrid)
- Innovative energy and thermal management is mandatory
- System efficiency for E-mobility

Research Tasks

- Holistic modeling for vehicle energy architectures
- Topics to significantly improve efficiency of future drives
- Novel energy conversion concepts

Key Results

- Robust modular fuel cell systems for drives and Range Extender
- Secondary energy usage with thermoelectric generators
- Brushless rotor supply for electrically excited synchronous traction machine
- Thermal high performance storage for increase of vehicle range (MonoTherm/DuoTherm)
- Integrated thermal management & modeling energy flows with in-house libraries



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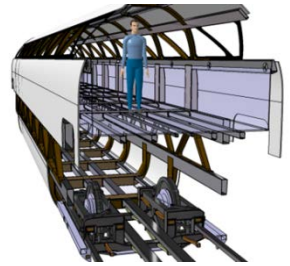
Institute for Vehicle Concepts – Innovation Field: Architectures and Material



Motivation

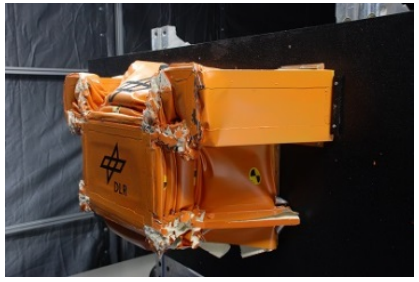
- Changed business models require new vehicle architectures, digitalization and new material and process

Research Tasks

- Lightweight construction concepts and new technical solutions for ground-based vehicles
- Integral processing methods, materials and constructions

Key Results

- CFRP-intensive multi-material design
- Structural sandwich components
- Adaptable crash-safe front module for alternative power trains
- Function integrated lightweight chassis
- Intelligent and safe structures (active and passive)
- Improved component crash test’s methods
- New crash concepts for rail vehicles



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Institute for Vehicle Concepts - Innovation Field: Systems and Technology assessment

Motivation

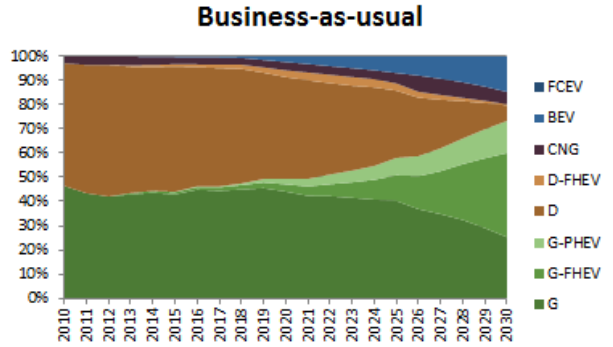
- Identification of technically feasible and economically reasonable solutions for a networked, sustainable and user-oriented mobility

Research Tasks

- Identification, Derivation, Motivation and Assessment of new vehicle concepts and technologies form an systemically view
- Focus: energy, emission, cost

Key Results

- Scenario model VECTOR21 / Demonstration / Scenario Lab
- Transport and Environment (VEU) / Urban Mobility
- Ecological Balance / Mass flow and emission measurement
- Development of the bus usage concept (Reallabor Schorndorf)
- Incentives for Cleaner Vehicles in Urban Europe (I-CVUE)
- Steering for Key Project „Key technologies for e-mobility
- Effect on employmenth and location caused by e-mobility



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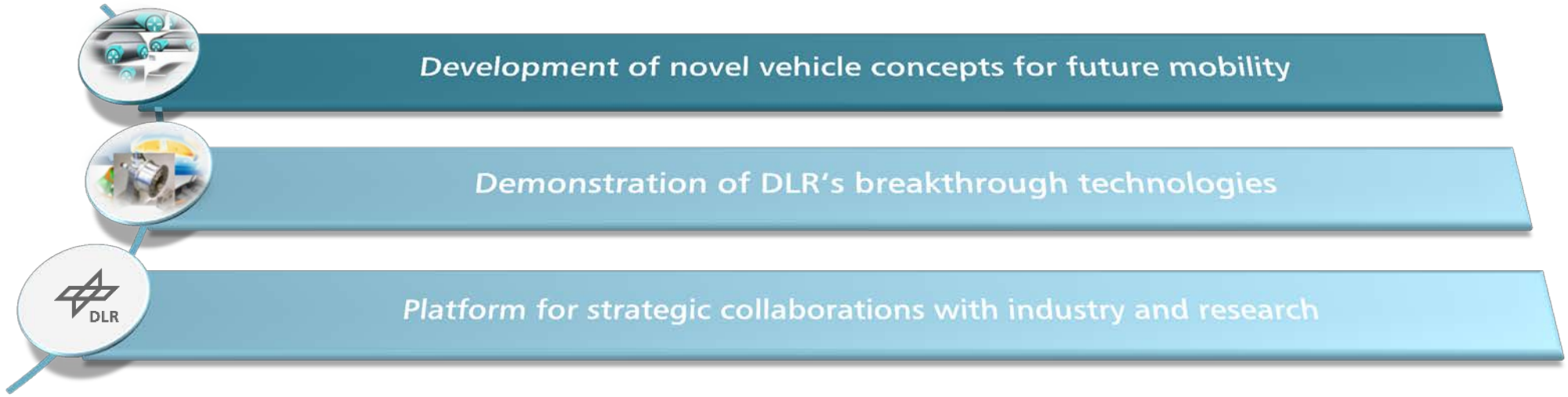
Institute for Vehicle Concepts - NextGenerationCar and NextGenerationTrain

DLR Meta Projects - NGC and NGT

Multiplier of DLR‘s system expertise and technology know-how
by cross-linking and integrating research institutes, infrastructures and demonstrators



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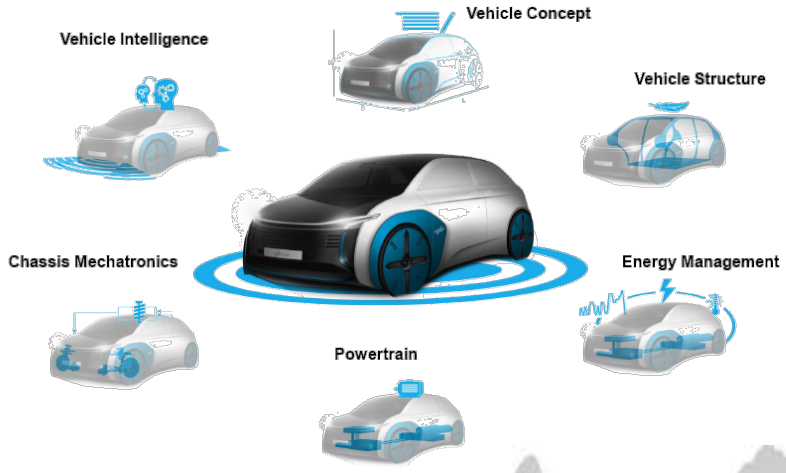
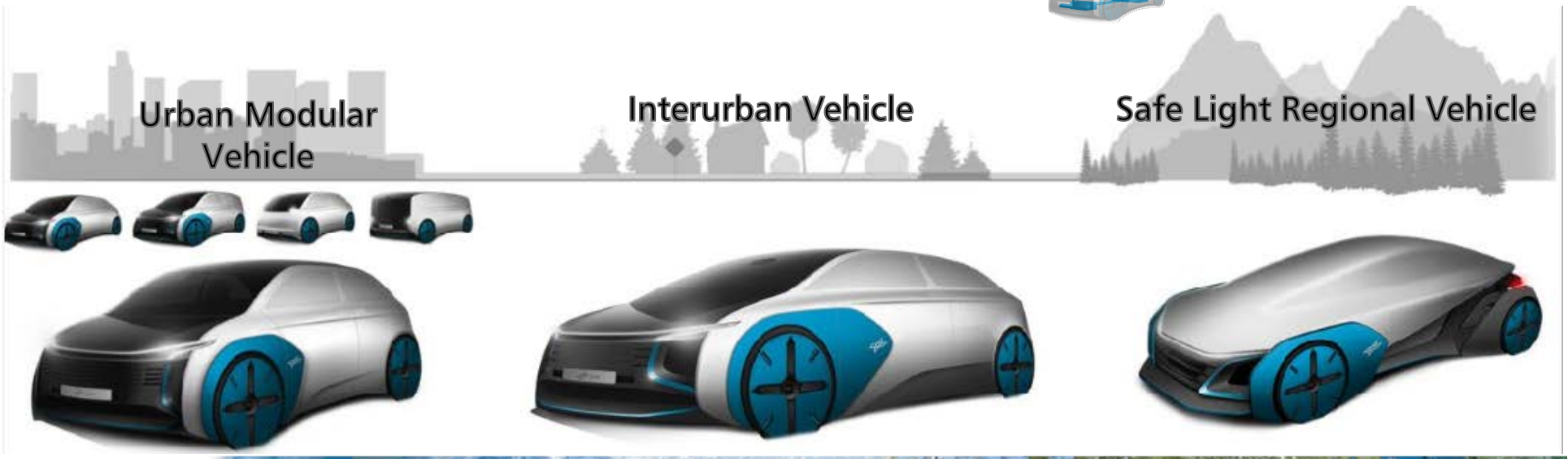
Institute for Vehicle Concepts – Meta project: NextGenerationCar

The project **Next Generation Car** (NGC) focuses DLR activities and research for road vehicle technology. Its contents are methods and technologies for a holistic development of road vehicles of the near and far of future:

- Vehicle Concepts
- Vehicle -structures and -materials
- Alternative Drive Technologies
- Chassis Mechatronics
- Energy Management
- Vehicle Intelligence





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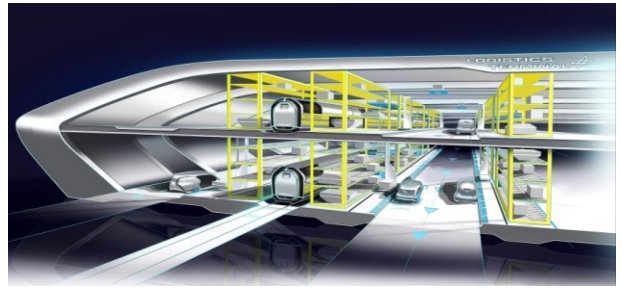
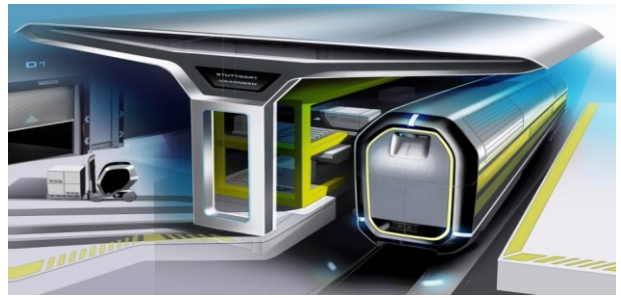
Institute for Vehicle Concepts – Meta project: NextGenerationTrain

The project **Next Generation Train** (NGT) focuses DLR activities and research for rail vehicle technology. In the frame of the meta project Next Generation Train all the cross-bounded competences of DLR in the field of conception and technologies of rail vehicles get deployed:

- Innovative rail vehicle concepts
- Lightweight construction and structures (Crash)
- Aerodynamics: wind tunnel makes stability in crosswinds observable
- Simulation of passenger flows / Station infrastructure
- Life cycle cost and high-speed route evaluation
- Simulating energy flows
- System dynamics of wheels and rails





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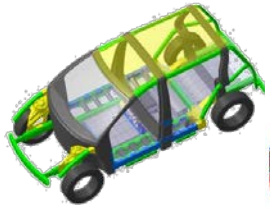
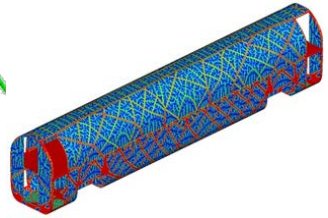
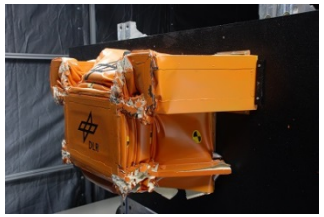
Institute for Vehicle Concepts – Expertise and Equipment

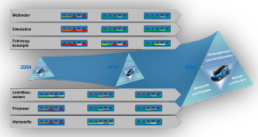
Expertise

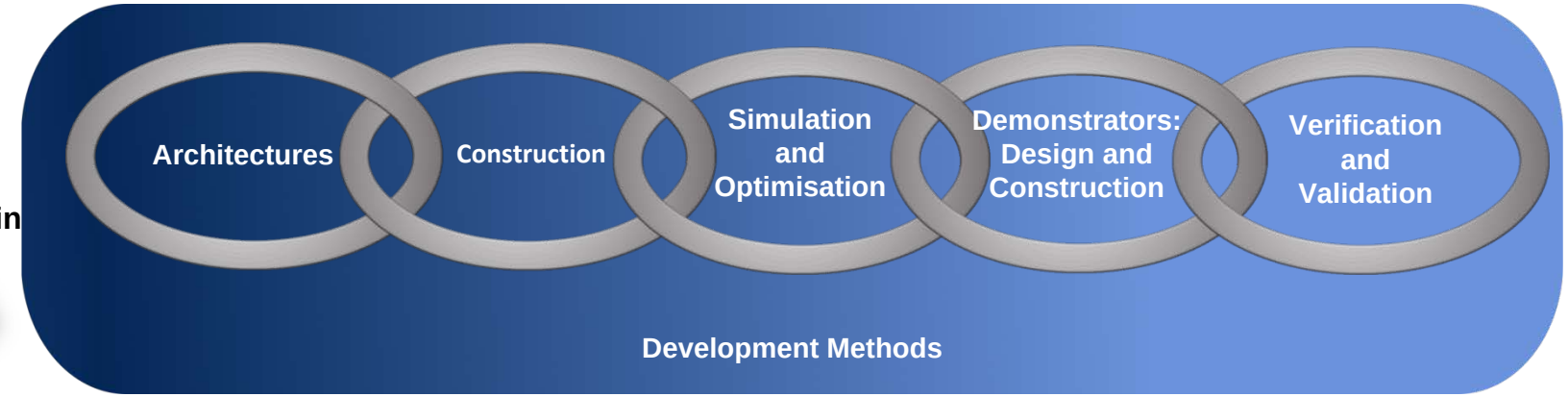






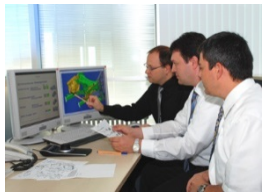
Research and Development Chain





Equipment

e.g. Concept-Lab



e.g. Catia

e.g. Calculation / Optimization Clusters

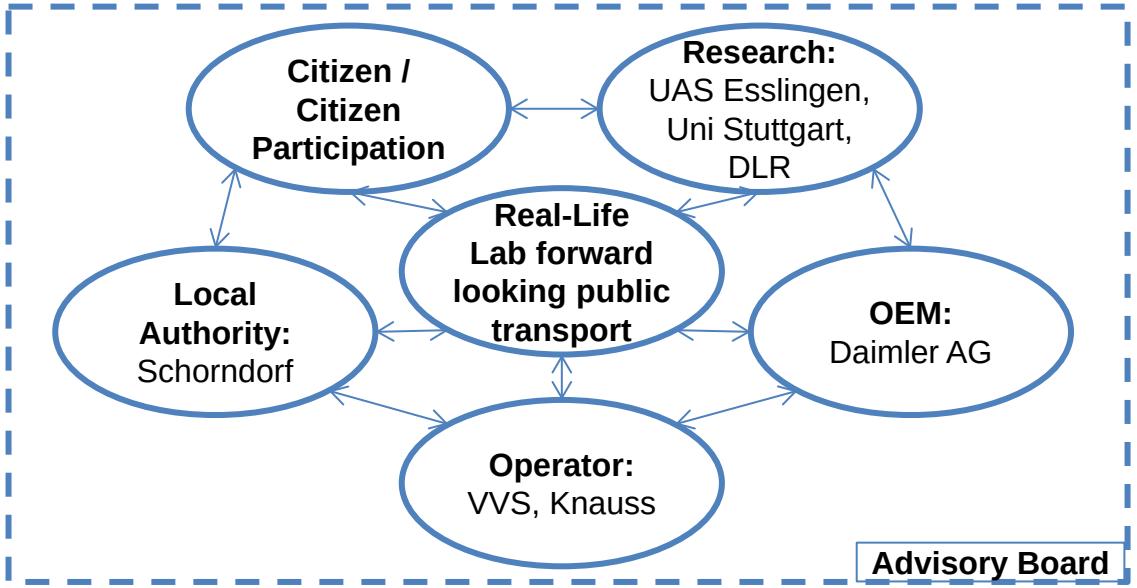
e.g. Additive Manufacturing Equipment

e.g. Crash-Test Facility, Static Loads Test Facility

Mobility of Tomorrow – Research Topics of DLR

Development of an Innovative and Optimized Structure of an Electrified Bus

- The idea of a innovative concept for an urban bus system
- The concept is a bus stopples urban quarter bus system
- Realization of the ideas and approaches as a pilot in real-life operation
- Funded by the ministry of science, research and art of Baden-Württemberg



SCHORNDORF DIE DAIMLERSTADT · VVS · Knauss Linienbusse

Mercedes-Benz Vans. Born to run. · DLR · Hochschule Esslingen University of Applied Sciences · Universität Stuttgart zirius

Baden-Württemberg Ministerium für Wissenschaft, Forschung und Kunst · Wissenschaft für Nachhaltigkeit

DLR

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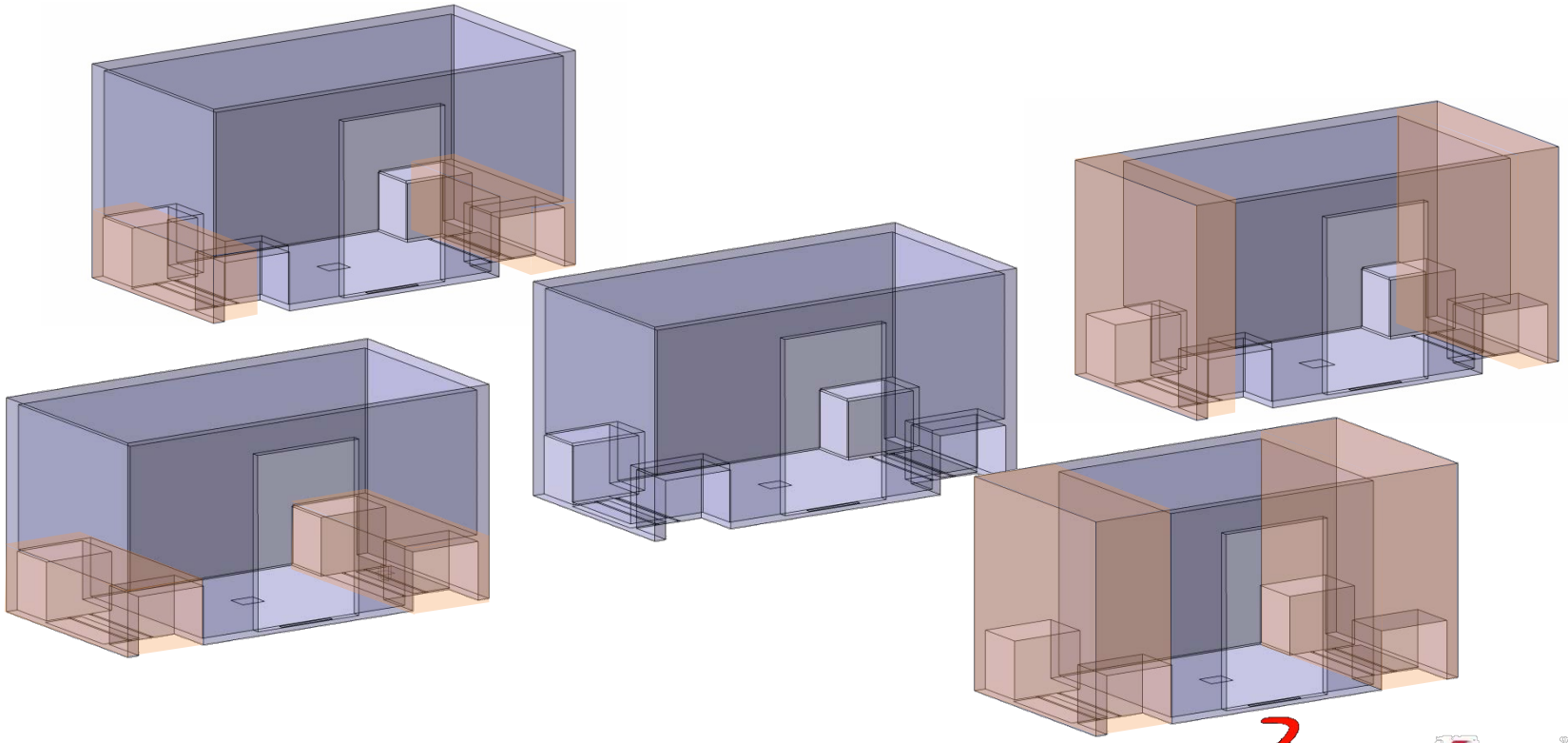
Optimized Structure of an Electrified Bus – Requirements and Topology Optimization

Requirements:

- Up to 10 persons
- Max. dimensions: 5m x 2.5m x 2.5m (L x W x H)
- Full electric
- Autonomous driving
- Barrier-free
- Turn Radius: <12m
- Max. Weight: 400kg
- Max. Displacement: <10mm
- Torsional Stiffness: >20kNm/°

Design Space(s) & Topology optimization:



CATIA Altair

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Optimized Structure of an Electrified Bus – Requirements and Topology Optimization

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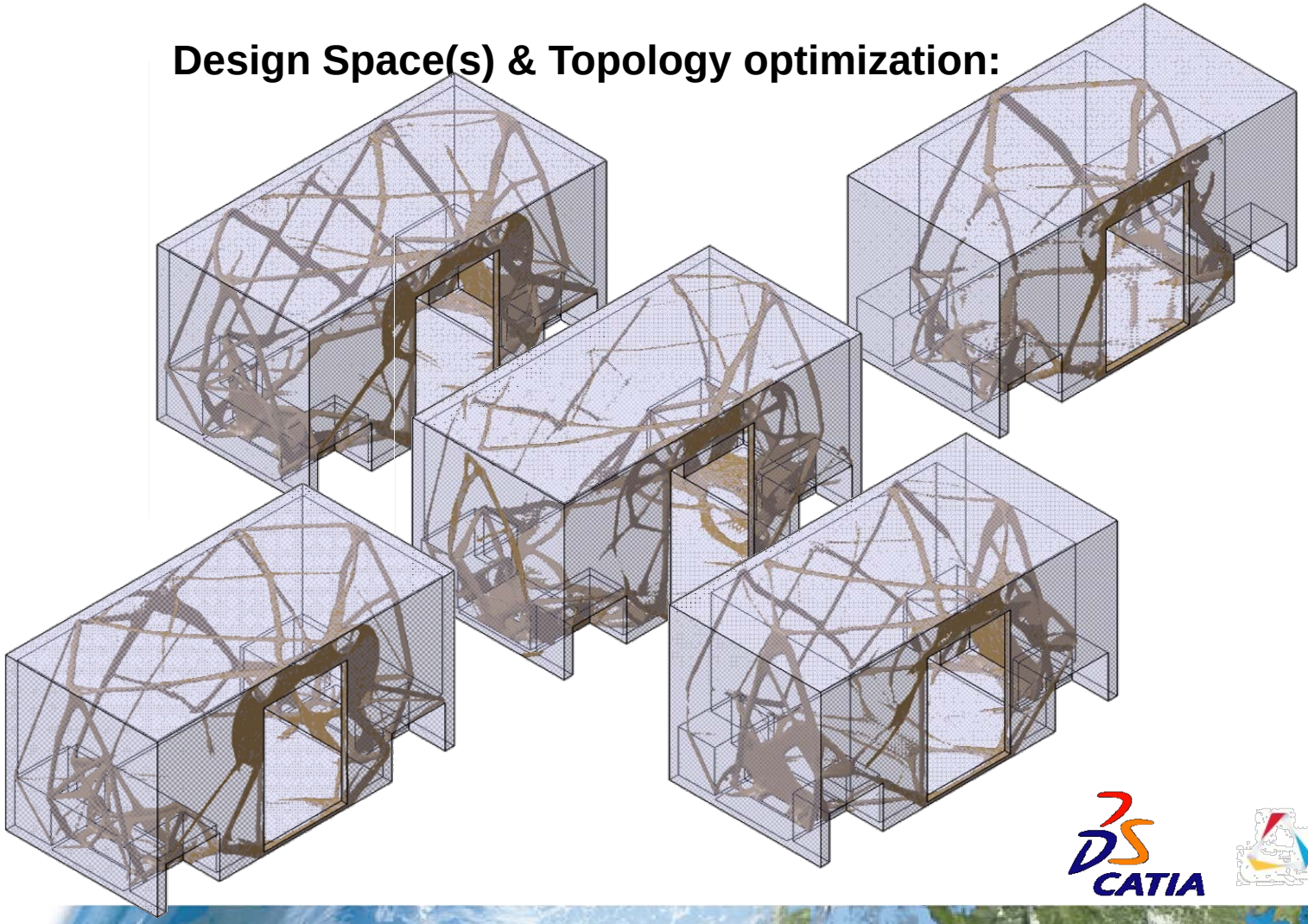

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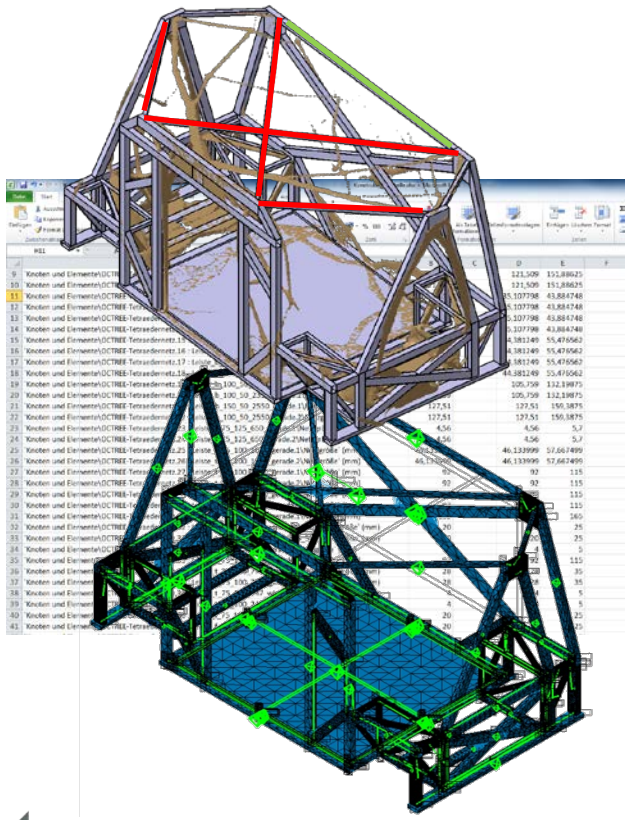
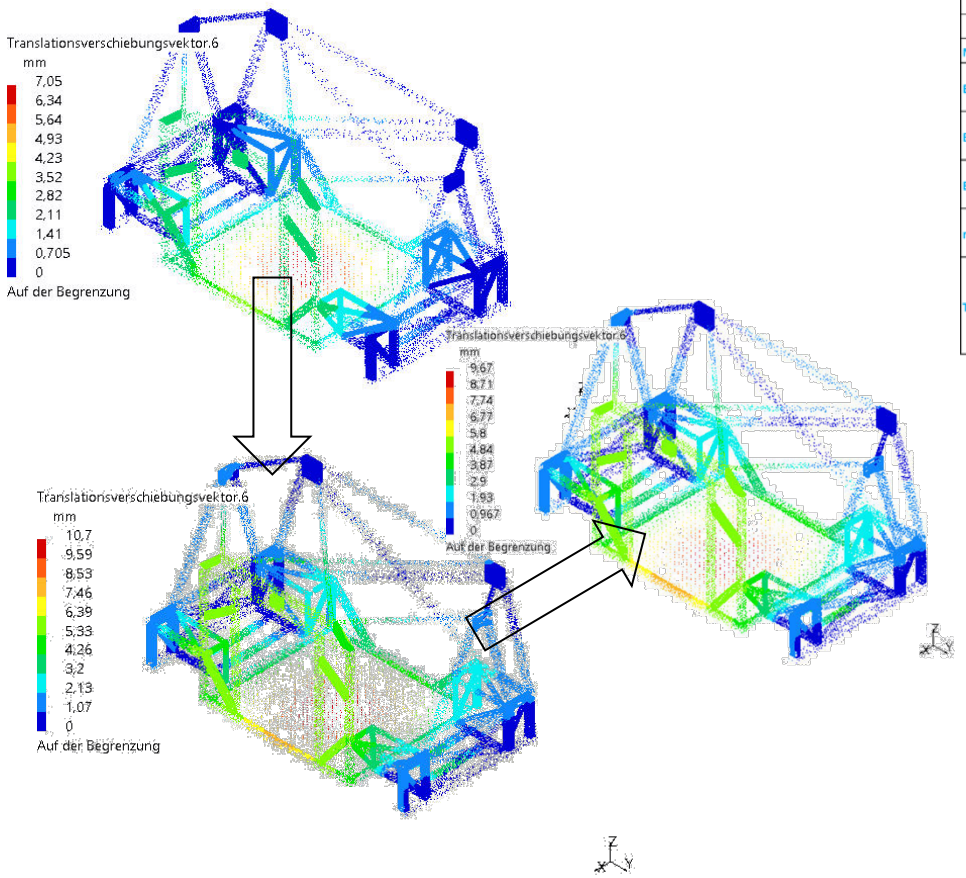
Optimized Structure of an Electrified Bus – Optimization of a Generic Design Structure

Simplified parametric FEM-Model



FEM-Solutions



Results

		2 mm		1 mm		optimiert	
		Total	%	total	%	total	%
Masse	Gewicht / kg	396,4	100	294,7	74,34	320	80,73
Einstiegsleiste	Spannung / MPa	60,1	100	122	203,00	120	199,67
	maximale Verschiebung / mm	2,05	100	4,11	200,49	3,88	189,27
Batterie	Spannung / MPa	54,7	100	153	279,71	152	277,88
	maximale Verschiebung / mm	1,59	100	4,32	271,70	4,32	271,70
Boden	Spannung / MPa	112	100	170	151,79	163	145,54
	maximale Verschiebung / mm	6,16	100	8,8	142,86	8,09	131,33
maximale Belastung	Spannung / MPa	176	100	337	191,48	330	187,50
	maximale Verschiebung / mm	7,05	100	10,7	151,77	9,67	137,16
Torsion	Spannung / MPa	125	100	241	192,80	187	149,60
	maximale Verschiebung / mm	9,57	100	15,2	158,83	14,7	153,61
	Verdrehwinkel / °	0,27	100	0,5	185,19	0,45	166,67
	Torsionssteifigkeit / Nm/°	37.000	100	20.000	54,05	22.222	60,06

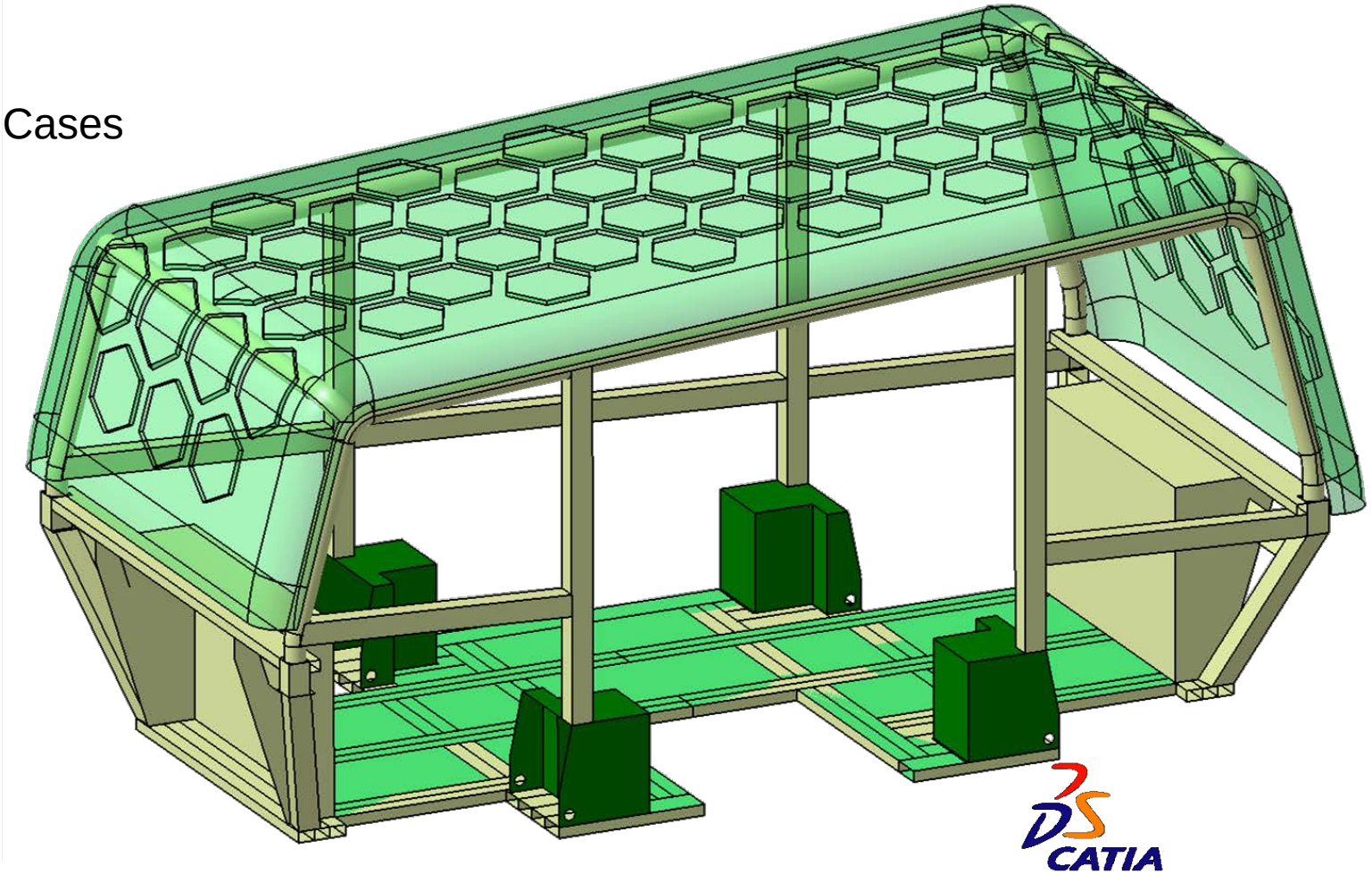
Weight: 320kg
Torsional Stiffness: 22kNm/°
Max. Displacement: 9.7mm

CATIA MasterThesis: A. Muth

Mobility of Tomorrow – Research Topics of DLR-FK

Optimized Structure of an Electrified Bus – Outlook and next Steps

- Adaption of Method to new Design
- Detailing of CAD-Data
- Detailed FEM-Simulation of all Load Cases



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